Transitions between symmetrical and asymmetrical gaits.
-a biomechanical analysis-

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Introduction: Gallop is a skipping gait in which one leg (the leading leg) is continuously kept in front of the other (3). This type of locomotion occurs spontaneously in the development of locomotion in children (1) and occurs sometimes in adults when descending stairs or a slope at high speed (2). Although gallop is a naturally occurring human locomotion pattern, research on human gallop is limited.

Methods: Fifteen female subjects with homogeneous stature were selected. They were asked to walk, run and gallop at preferred speed and to perform multiple transitions from walking to running (WRT), galloping to running (GRT) and walking to galloping (WGT). Subjects were equipped with 59 reflective markers and performed the trials on an overground walkway with 6 built-in forceplates and 12 infrared cameras (Pro Reflex, Qualisys). Kinematics and kinetics were calculated using commercial software (Visual 3D, C-motion).

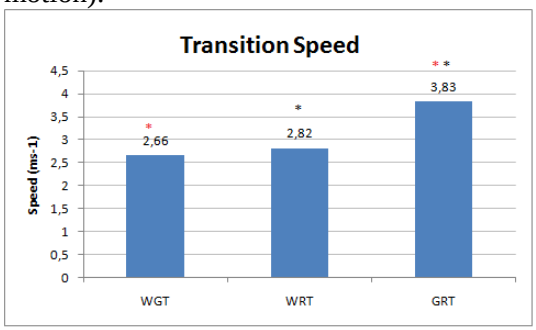

Fig.1: transition speed for WGT, WRT and GRT. *and* are significant differences between transitions (p<0,01)

Results: Subjects consistently used the same leading leg during gallop. Joint kinematics and kinetics showed differences between the leading and trailing leg in gallop. Transition speed of GRT ($3.83\pm0.34 ms^{-1}$) was significantly higher than transition speed of WGT ($2.66\pm0.24 ms^{-1}$)($p<0.01$) and WRT ($2.82\pm0.26 ms^{-1}$)($p<0.01$) but no statistical difference was found between WGT and WRT ($p=0.410$)(fig.1).

A clear transition step was seen in the WRT and the GRT based on joint kinematics, kinetics, and patterns of mechanical energy. In the WRT, GRT and WGT the swing phase prior to the transition step showed greater (dorsi)flexion in the ankle, knee and hip in comparison with previous walking/galloping steps. In the WGT ($2.66\pm0.24 ms^{-1}$) also the stance phase in the step before transition showed more (dorsi)flexion in the ankle, knee and hip. When subjects initiated the WGT when the leading leg was not in front, they showed some inconsistent intermediate running/skipping steps before they started galloping.

Conclusions: Gallop is appropriately called an asymmetrical gait pattern as the leading and trailing leg execute a different movement. Adults seldom switch spontaneously from walking to galloping so the WGT is supposed to be planned. Still the initiation of transition seems to occur spontaneously because transition sometimes initiated when the leading leg was not in front. If the transition would occur intentionally, one would expect that transition only initiates when the leading leg is in front. Transition speed is very similar for WGT and WRT so it could be that a similar mechanism (arising in the acceleration from walking) determines when the transition occurs.

Transition is prepared in the same way in the WRT and the GRT. There is a limited preparation in the swing phase preceding the actual transition step. In the WGT two transition steps were seen. As both legs carry out a different movement in gallop, it seems like each leg needs a transition step to alter the new gait configuration.

The transition from an asymmetrical gait pattern to a symmetrical gait pattern (GRT) seems easier to perform than a transition from a symmetrical gait pattern to an asymmetrical gait pattern (WGT) as at least two steps were necessary to make the transition in the WGT in comparison with one step in the GRT. The gait pattern before the transitions, seems to determine the instant of transition initiation (similarity between **W**GT and **W**RT). The gait pattern after transition seems to be important in the way the transition is prepared (similarity between W**R**T and G**R**T).

References

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